Appendix A

TECHNICAL APPENDIX

**METHODOLOGY FOR COMPUTING
THE ECONOMIC BENEFIT
OF NONCOMPLIANCE**

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A. INTRODUCTION

This technical appendix explains the methodology used in the BEN computer program to calculate the economic benefit from delaying compliance with environmental regulations. This first section is an introduction to the methodology followed in the economic benefit calculation. Underlying assumptions are discussed in the second section, and the third section presents and explains the mathematical formulae used in BEN. The final section provides a sample economic benefit calculation.

BEN follows a four-step procedure to compute the economic benefit of delayed compliance. First, BEN calculates the incremental after-tax cash flows that the violator would have experienced had it made the expenditures necessary to come into compliance on time. BEN includes the present value of cash flows attributable to future replacements of pollution control equipment as well as those associated with complying initially. BEN converts these cash flows to their "present value" as of the noncompliance date. This is the hypothetical "on-time" case. Second, BEN calculates the present value (as of the noncompliance date) of the cash flows that the violator experiences when it makes the expenditures necessary to come into compliance after the delay. This calculation also takes into account the replacement of pollution control equipment at the end of its useful life. This is the "delay" case. Third, BEN calculates the difference between the present values of the cash flows associated with complying on-time and the cash flows associated with complying after the period of delay. This difference is the initial economic benefit. Finally, BEN calculates the earnings accrued by the violator on the initial economic benefit between the noncompliance date and the penalty payment date; this represents the violator's economic benefit as of the penalty payment date.

In BEN, we are calculating the economic benefit a firm earned from noncompliance. BEN is not calculating "damages." In a damages calculation, the aggrieved party is attempting to retrieve losses that were incurred as a result of the accused's actions. In an environmental violation, damages may or may not have

occurred, but that is not what the BEN calculation is attempting to capture. Instead, BEN attempts to assess the amount of money that the company expected to earn from its savings in pollution control costs.

1. Cash Flows Resulting from Complying On-Time

The BEN model requires users to identify the month and year when noncompliance began and the month and year when compliance was (or will be) achieved. The former is referred to as the "noncompliance date," and the latter as the "compliance date." BEN assumes that all capital and one-time expenditures should have been made by the noncompliance date, and that annual expenditures should have begun at the same time.

In estimating the cash flows that would have resulted from complying on time, BEN first expresses all cost inputs in dollars of the noncompliance year. These costs are grouped by the user into three categories: capital investments, one-time nondepreciable expenditures and annual costs. BEN then converts these costs into cash flows beginning at the noncompliance date. Each cost category is described separately below. More detailed discussions of the three types of cost inputs appear in Chapter 4.

a. Capital-Related Cash Flows

Capital-related cash flows include the direct costs and indirect financial impacts associated with a capital investment, both initially and over time. Initially, the violator makes a capital outlay to purchase and install pollution control equipment. At the same time, the amount of any applicable investment tax credit serves to reduce the initial cash outflow.[1] There are also indirect annual impacts associated with depreciating pollution control equipment. Depreciation does not itself involve a cash outflow; however, its effect is to reduce pre-tax income and hence to reduce income tax payments. The tax benefit associated with depreciation in subsequent years are cash inflows that reduce the net cost of the equipment.

BEN allows you to specify whether the capital cost is a one-time or recurring cost. One-time capital investments will have a lower present value than will recurring capital costs.

b. One-Time Nondepreciable Expenditure

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[1] BEN applies the Investment Tax Credit to capital investments made in 1985 and before.

A one-time nondepreciable expenditure occurs initially and is not repeated. If the expenditure is tax-deductible, the tax benefit is subtracted from the expenditure amount to arrive at the net cash outflow. If the expenditure is not tax-deductible, the cash outflow equals the entire expenditure amount.

c. Annual Costs

The third category of cash flows consists of those resulting from annual expenditures. The most typical annual costs are for operation and maintenance of pollution control equipment. Other annual costs include the leasing of equipment or monitoring of pollution clean-ups. Annual expenses are tax deductible, and BEN calculates their after-tax value in each year. These cash outflows are assumed to increase each year because of inflation.

2. Present Value of Cash Flows

After all present and future direct costs and indirect financial impacts have been determined and arrayed over time, they are converted into a present-value figure as of the noncompliance date. This conversion is necessary because two cash flows of equal dollar values occurring in different years would not have equal financial impacts on the violator. This differential arises because there is a "time value of money." In other words, assuming that the violator can invest its funds at some positive rate of return, if a dollar of expenditure can be postponed for one year, that dollar can be invested in the interim. At the end of that year, the expenditure can be made; and the return on the investment during the intervening period accrues as a benefit to the violator.

The technique used to compensate for this effect is called "discounting". Discounting converts the value of future cash flows to amounts that are equivalent in terms of constant-year dollars. For example, suppose that a firm wants to make a $100 investment next year. If the firm's investment alternatives today are such that it can earn a 12 percent annual return, the firm could invest $89.29 today and that amount would grow to $100 in one year.[2] Thus, $89.29 is called the "present value," at 12 percent, of a $100 cash flow one year in the future. Similarly, if $79.72 were invested at 12 percent, it would grow to $89.29 in one year, and to $100 by the end of the second year. Thus, $79.72 is the present value, at 12 percent, of a $100 cash flow <u>two</u> years hence. The rate used in determining present values, 12 percent in this case, is called the "discount rate."

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[2] Twelve percent of $89.29 = $10.71, and $89.29 + $10.71 = $100.00

The general formula for discounting is:

$$\text{Present Value (PV)} = \frac{F_j}{(1 + E)^j}$$

where: F_j =   the "future value" cash flow expected in year j

E =   the annual discount rate in decimal form
(e.g., .12 for 12 percent)

j =   the number of years in the future in which the cash flow occurs; and
$j = 0$ is the year to which you are discounting.

Applying this technique to each year's cash flows converts them into their present-value equivalents. The sum of these individual values represents the equivalent after-tax cost, in terms of a single present value, of the cash flows arising out of the requirement to comply with environmental regulations.

Except for any one-time expenditures, the cash flows associated with investing in and operating pollution control equipment are repeated continually in the future, as the equipment is replaced after each useful life. All of these cash flows associated with future replacements are also discounted back to a present-value equivalent.

3.   Present Value of Cash Flows
       Associated with Delayed Compliance

       BEN calculates the present value of the cash flows associated with complying at the end of the delay period, based on the following assumptions:

1.   The delayed cash flows will be similar to the on-time cash flows in that they will have the same sequence of capital expenditures, one-time nondepreciable expenditures, and annual cost flows. The after-tax cash flow amounts might differ, however, because tax provisions in effect during the years following the compliance date might differ from those in effect during the years following the noncompliance date.

2.   Each delayed cash flow will be separated in time from the corresponding on-time cash flow by the number of months of noncompliance.

3.   The nominal value of each delayed cash flow will be greater than the corresponding on-time cash flow because of the impact of inflation over the period of delay.

4.   Economic Benefit of Delayed Compliance

       The present values of both sets of cash flows (i.e. those associated with the "on-time" case and those associated with the "delay" case) are then compared. The present value of the second set will usually be lower, reflecting the fact that delaying compliance yields a financial benefit to the violator. The initial economic benefit the violator gains from delaying compliance is the difference between the present values of the first set of cash flows and the second set of cash flows. To obtain the economic benefit as of the penalty payment date, the economic benefit as of the noncompliance date is increased at the discount rate for the number of months between the noncompliance date and the penalty payment date. This is done to account for the amount of money the violator earned on the economic benefit gained as of the noncompliance date, compounded monthly over time until the penalty payment date. BEN assumes that the violator invested the net economic benefit in plant and equipment similar to the violator's existing investments in terms of risk and financing. In addition, because we assume that the violator is an average company, BEN applies the weighted-average rate of earnings that corporations expect to earn over the long-term to cover the cost of both debt and equity capital.

B. **UNDERLYING ASSUMPTIONS**

Several important assumptions are made in calculating the economic benefit of delay as described in this appendix. Many of these assumptions were only implicit in the discussion in the previous section. Each major assumption is identified and explained below.

1. **Discounting Assumptions**

The cash flows in BEN are generally discounted at a rate that reflect their overall risk. As described above, the standard value discount rate used in BEN is the weighted-average cost of capital. Chapter 4 of the manual contains a description of how this value is calculated.

2. **Application of the Inflation Rate**

The inflation rate input (either the standard value or a user-specified value) is used to convert all dollar inputs -- the capital investment, one-time expenditure, and annual operating and maintenance costs -- into dollars of the noncompliance year.

Annual costs and future replacement cycle expenditures are also inflated using the annual inflation rate. BEN also uses this same inflation rate to derive the delayed costs from the on-time costs (i.e., investment, one-time, and annual costs).

3. **Mid-Year Cash Flow Occurrence**

BEN calculates periodic cash flows, such as annual costs and depreciation tax benefits, as if they occur once each year at mid-year. These mid-year cash flows begin six months after the capital investment and one-time expenditure are incurred. By assuming that these costs occur at mid-year, BEN averages the costs across the year.

4.   Non-Deductibility of the Civil Penalty

In calculating the cash flows from which the economic benefit of delayed compliance is computed, BEN takes into account the normal tax consequences of expenses, depreciation, and so forth. On the other hand, BEN assumes that the total penalty being calculated, including the economic benefit component, is not deducted from the violator's income for tax purposes. This comports with current IRS policies.

5.   Continuous Sequence of Replacement Cycles

The model assumes that pollution control equipment is replaced at the end of its useful life, at a cost that reflects the rate of inflation. This process continues repeatedly, implying that the underlying source of pollution is never eliminated and that the cost of the pollution control remains the same taking inflation into account. In BEN, recurring capital and annual cash flows associated with pollution control equipment are incurred over an infinite number of replacement cycles in both the delay and the on-time cases. The one-time capital or nondepreciable expenditure, however, is incurred only once.

C.   DERIVATION OF MATHEMATICAL FORMULAE

This section describes the procedure for calculating the economic benefit of delayed compliance. The explanation is fairly detailed, including some of the mathematical formulae used in the BEN model. Not all of the variables described below are actually used in BEN, since the program combines some steps for the sake of efficiency. A separate subsection explains the procedures used to calculate the values in the detailed cash flow table provided in output Option 3. All symbols are listed and defined in Exhibit A-1.

Exhibit A-1

DEFINITION OF SYMBOLS

COST	=	Cost of compliance with environmental regulations as entered
COST$_{DEF}$	=	Cost of compliance with environmental regulations in noncompliance-year dollars
DEP$_j$	=	the amount of depreciation in year j
DF$_j$	=	the factor used to discount after-tax annual expenses and depreciation tax savings
d$_j$	=	the fraction of the original asset value depreciated in year j
E	=	the annual discount rate
E$_m$	=	the monthly discount rate
EC$_{BEN}$	=	the present value of the economic benefit from delay as of noncompliance date
EXP	=	the one-time nondepreciable expenditure incurred to comply with environmental requirements
FV$_{BEN}$	=	the future value of the economic benefit
I	=	the annual rate of inflation for expenditure made to comply with environmental requirements
I$_m$	=	the monthly inflation rate
IDFLT	=	the number of years between the noncompliance year and year in which the cost is expressed
II	=	the initial capital investment for pollution control
II$_{ADJ}$	=	the depreciation basis of the initial capital investment
INV	=	investment cash flow

DEFINITION OF SYMBOLS
(continued)

ITC	=	the investment tax credit
i,j	=	indices, usually indicating the year in which a cash flow occurs
L	=	the number of months of delayed compliance
MTR$_j$	=	the marginal income tax rate (federal & state) in year j
N	=	the useful life of pollution control equipment in years
OM$_j$	=	the annual (operating and maintenance) expense in year j
ONE$_0$	=	the after-tax cash flow associated with the one-time expenditure
PRIN$_j$	=	the principal repayment in year j
PV	=	the present value of a cash flow or cash flows
PV$^1_{PCE}$	=	present value of all cash flows in first cycle
PV$^2_{PCE}$	=	present value of all cash flows in second cycle
PV$_{PCE}$	=	present value of all cash flows in all cycles
t$_{ITC}$	=	the investment tax credit rate
TXSVDP$_j$	=	the tax savings associated with depreciation expense in year j
TXSVOM$_j$	=	the after-tax cash flow from operating and maintenance expenses in year j

Note that BEN converts all rates (e.g., marginal tax rates, discount rate), which the user must enter as percentages, to a decimal format by dividing by 100. The decimal form (e.g., .12 for 12 percent) is required in all of the formulae used in calculating the economic benefit. All of the rates used in the formulae below are expressed in decimal form.

1.   **Cash Flows as of Required Compliance Date**

This section describes the cash flows associated with complying on-time (as of the noncompliance date). The costs of compliance with environmental regulations can be categorized into three types of cash flows: those associated with an initial capital investment, annual costs, and an initial one-time non depreciable expenditure. Subsections 1, 2 and 3 below explain each of these.

Before any of these costs are used in the formulae, BEN first converts the costs into dollars of the year compliance should have been achieved (i.e., the noncompliance year). The model performs this adjustment using the dollar-year entered with the cost figure. If the dollar-year is later than the noncompliance year, the cost is deflated as follows:

(1)
$$COST_{DEF} = \frac{COST}{(1 + I)^{IDFLT}}$$

where: $COST_{DEF}$ =   the cost expressed in noncompliance-year dollars

$COST$ =   the cost as entered

I =   the annual inflation rate

$IDFLT$ =   the number of years between the noncompliance year and the cost's dollar-year

When the dollar-year occurs before the noncompliance date, the cost must be inflated as follows:

(2)
$$COST_{DEF} = COST \times (1 + I)^{IDFLT}$$

No adjustment is necessary when the dollar-year is the same as the year of the noncompliance date.

Each of the values discussed below is expressed in noncompliance-year dollars. Assume that BEN has already performed the appropriate deflating or inflating.

a.   Capital Investment

The initial cash outflow resulting from the capital investment is the total capital cost of the pollution control equipment. This capital cost, denoted by II, is in noncompliance-year dollars. The investment tax credit (ITC), if applicable, is a cash inflow which must be subtracted from the initial investment. The ITC is equal to the product of the investment tax credit rate applicable in that year and the capital cost:

(3)
$$ITC = II \times t_{ITC}$$

where: t_{ITC} =   investment tax credit rate

In this model, the ITC rate is set at 10 percent for investments made in 1985 and before, and at 0 percent for investments made in 1986 and after. For not-for-profit entities, the ITC is set at 0 percent regardless of the year.

Also associated with the capital investment are tax benefits resulting from depreciation. Annual depreciation is the product of the capital cost, adjusted for any ITC taken, and the depreciation fraction in year j

$$\text{DEP}_j = \text{II}_{\text{ADJ}} \times d_j$$

(4)

where: DEP_j = amount of depreciation in year j

II_{ADJ} = the depreciation basis; equal to the original initial investment adjusted, if necessary, for any ITC taken

d_j = the fraction of the adjusted initial investment cost depreciated in year j

For investments made before 1987, the model sets the depreciation life at five years and uses a straight-line depreciation schedule, so the depreciation percentage in each year is constant at 20 percent. Thus, d_j = .20 for the first five years of the equipment's useful life, and d_j = 0.0 for the remainder of the useful life. This assumption was made to approximate the two possible depreciation schedules that could be applied to pollution control investments during the pre-1987 period: (1) the Accelerated Cost Recovery System's (ACRS) five-year schedule that applies to most types of equipment, and (2) the 60-month rapid amortization procedure, which could be used for certain pollution control investments.

For investments made in 1987 and later, the model uses the double-declining balance depreciation method (with half-year convention) for years one to four and converts to straight-line depreciation for years five to seven. This method is prescribed by the revised tax law's Modified Accelerated Cost Recovery System (MACRS) and uses a seven year depreciation life.

The depreciation basis, II_{ADJ}, is equal to 100 percent of the original initial investment, II, in all years except 1983 through 1985. In those years, as was required then by tax law, the basis is reduced by one-half of the ITC taken.[3]

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[3] Since BEN assumes a 10% ITC on investments made in years including 1983 through 1985, the depreciation basis during this period equals 95% of the original initial investment.

The cash flow impact from depreciation is the reduced income tax liability that results from deducting depreciation as an expense. These deductions are assumed to occur annually at mid-year. The tax benefit from depreciation is calculated by multiplying the depreciation expense for each year by the marginal tax rate in effect in that year. The tax benefits are cash inflows that reduce the cost of compliance. The model calculates the tax benefit from depreciation later in the program when the cash flows are discounted (see Equation 10).

b. One-Time Nondepreciable Expenditure

The one-time nondepreciable expenditure, like the capital investment, occurs initially. Expressed in noncompliance-year dollars, it is denoted as EXP. If the user indicates that the nondepreciable expenditure is not tax-deductible, the initial cash outflow (ONE_0) is equal to the one-time expenditure:

(5)
$$ONE_0 = EXP$$

If the one-time nondepreciable expenditure is tax-deductible, meaning that it serves to reduce the violator's taxable income and consequently its tax liability, the expenditure must be adjusted to an after-tax basis. This adjustment is accomplished by multiplying the expenditure amount by one minus the marginal tax rate.

(6)
$$ONE_0 = EXP \times (1 - MTR_j)$$

where: MTR_j =   the violator's marginal income tax rate in effect in year j

c. Annual Costs

The initial annual cost, expressed in noncompliance-year dollars, is denoted by OM_0. Annual costs in the model increase at the rate of inflation. As with depreciation cash flows, annual cash flows are assumed to occur at mid-year. The first annual cash flow (OM_1) occurs in the middle of the first year, six months after the initial capital cost. The inflation rate is thus applied for half a year:

$$OM_1 = OM_0 \times (1 + I)^{1/2}$$

where: I   =   the annual inflation rate

This equation can be generalized for any year j, for j equal to or greater than 1:

$$(7) \qquad\qquad OM_j = OM_0 \times (1 + I)^{(j-1/2)}$$

Since the annual costs are tax deductible, the after-tax cash flow associated with an annual expense is the product of the annual cost and a factor equal to one minus the marginal tax rate. The model adjusts the annual cash flow to after-tax dollars later in the program when the cash flows are discounted (see Equation 12).

2. Discounting Cash Flows

The cash flows associated with the on-time case, as calculated above, are then discounted to the present value as of the noncompliance date. Those cash flows occurring at the noncompliance date are already expressed in present-value terms; thus, no discounting of these is necessary. Each cash flow occurring annually, such as the depreciation tax benefit and after-tax annual costs, must be discounted. The following explanation is divided into two parts: The first discusses all the cash flows associated with capital and annual expenditures; the second discusses cash flows associated with the one-time nondepreciable expenditure.

a. Capital and Annual Expenditure Cash Flows

The net initial cash flow associated with a capital investment in pollution control equipment is the capital

$$(11) \qquad PV_{DEP} = \sum_{j=1}^{N} PV_{DEPj}$$

cost minus the investment tax credit:

$$(8) \qquad PV_{IN} = II - ITC$$

Using equation (3), this can be restated:

$$(9) \qquad PV_{IN} = (II - (II \times t_{ITC})$$

$$= II \times (1 - t_{ITC})$$

The present value of depreciation-related cash flows for any year j is:

$$(10) \qquad PV_{DEPj} = \frac{DEP_j \times MTR_j}{(1 + E)^{(j-1/2)}}$$

where: DEP_j =   depreciation in year j

MTR_j =   marginal tax rate in year j

E =   the annual discount rate

The marginal tax rate in effect in that year is applied to depreciation in that year to calculate the depreciation tax benefit. In discounting the annual tax benefit for year j, the exponent is "j - 1/2" because each cash flow in the model occurs at mid-year. The present value of all the annual depreciation tax benefit cash flows (PV_{DEPj}) over the N-year useful life is calculated by summing:

where: PV_{DEP} = the present value of all depreciation-related cash flows

Similarly, the present value of after-tax annual cash flows for any year j is:

$$(12) \qquad PV_{OMj} = \frac{OM_j \times (1 - MTR_j)}{(1 + E)^{(j-1/2)}}$$

where: E = the annual discount rate

The present value of annual expenditures over the equipment's useful life of N years is the sum of the present values for each year:

$$(13) \qquad PV_{OM} = \sum_{j=1}^{N} PV_{OMj}$$

The present value of all cash flows resulting from the capital and annual O&M expenditures required to comply with environmental regulations throughout the initial useful life cycle of the controls is equal to the combination of the present values of the three associated cash flows: the initial capital investment net of ITC, the depreciation tax benefit, and the after-tax annual O&M costs, taken from equations (9), (11), and (13), respectively:

$$(14) \qquad PV_{PCE}^{1} = PV_{IN} - PV_{DEP} + PV_{OM}$$

The present value of all cash flows associated with the initial useful life cycle of the pollution control equipment must next be expanded to include the present value of cash flows in <u>all</u> future replacement cycles. This can be accomplished by first calculating the second cycle of cash flows, which is the first replacement cycle. The BEN model assumes that the most recent tax law provisions apply to the cash flows in every year of this second cycle, and in all subsequent replacement cycles. Therefore, BEN calculates cash flows for the second cycle by inflating all investment and annual costs to the end of the first useful life and applying the new tax law provisions. The present value of this second cycle of cash flows as of year N, when the original equipment wears out, is

denoted PV^2_{PCE}.

The present value of the cash flows from the second cycle and all future replacement cycles is calculated by summing:

$$(15a) \quad = PV^2_{PCE} + PV^2_{PCE} \times \left[\frac{(1 + I)^N}{(1 + E)^N}\right] + PV^2_{PCE} \times \left[\frac{(1 + I)^2}{(1 + E)^2}\right]$$

$$= PV^2_{PCE} \times \left[\frac{1}{1 - \left[\frac{1 + I}{1 + E}\right]^N}\right] \qquad FOR \ E > I$$

where: N $=$ the useful life of the equipment (in years).

The present value of these replacement-cycle cash flows as of the noncompliance date is then determined by discounting:

$$(15b) \quad PV^*_{REP} = \frac{PV_{REP}}{(1 + E)^N}$$

Where the capital investment is a one-time, not a recurring investment, PV^*_{REP} only includes future annual expenditure cash flows. Capital investment and depreciation cash flows are zero.

The present value of the cash flows from the original cycle and all future replacement cycles is calculated by summing:

$$PV_{PCE} = PV_{PCE}^1 + PV_{REP}^*$$

b.   The One-Time Nondepreciable Expenditure Cash Flow

The present value of the cash flow associated with a one-time nondepreciable expenditure is simply the initial after-tax cash flow as expressed in equation (5) or (6):

(16) $PV_{ONE} + ONE_0$

This one-time cash flow is not repeated in subsequent years. Therefore, the calculations of equations (15a), (15b) and (15c) are not required for this cash flow.

c.   Total Cash Flow

The total present value of cash flows associated with the pollution control-related capital investment, annual O&M expenditures, and a one-time nondepreciable expenditure is:

(17) $PV = PV_{PCE} + PV_{ONE}$

This is the total present value of complying on time, as of the date compliance was required.

3.   The Economic Benefit of Delayed Compliance

The economic benefit of delayed compliance is the difference between the present value of complying on-time and the present value of complying at the end of the delay period. The total figure calculated in (17) above is the total present value of complying on-time, as of the noncompliance date. The cash flows associated with complying after the delay period are similar to those associated with complying on-time, as explained in the above two sections. However, the delay case cash flows differ from the on-time cash flows for two reasons: (1) inflation, and (2) differential tax provisions. Each of these reasons is discussed below.

The cost of complying after the delay period is generally higher (in nominal terms) than the cost of complying on-time because of the impact of inflation. Each cost of delayed compliance, as of the day on which compliance is actually achieved, is inflated over the delay period from the on-time compliance cost. For example, the one-time expenditure in the delay case is given by:

$$(18) \qquad ONE^*_{DELAY} = ONE_0 \times (1 + I_m)^L$$

where: I_m =   the monthly inflation rate (derived from I, the annual inflation rate)
               L =   the number of months of delay

The other two cost categories are similarly inflated.

BEN then calculates the delay case cash flows from these inflated costs according to the tax law provisions that apply to each year of the first cycle of the delay case. Because the first cycle of the delay case covers different years than the first cycle of the on-time case, the application of different tax law provisions might create a different pattern of tax impacts. BEN calculates the present value of the delay case cash flows and adds the replacement cycle cash flows, calculated as described above for the on-time case. The total present value of the delay case cash flows as of the compliance date is denoted PV^*_{DELAY}.

The present value of the delayed cash flows, as of the day on which compliance should have been achieved (i.e., the "noncompliance" date), is given by discounting:

$$(19) \quad PV_{DLA} = \frac{PV^*_{DELAY}}{(1 + E_m)^L}$$

where: E_m =   the monthly discount rate (derived from E, the annual discount rate)

The economic benefit from delay is thus the difference between these two present values:

$$(20) \quad EC_{BEN} = PV - PV_{DLA}$$

This economic benefit figure is then valued as of the expected penalty payment date, reflecting the fact that the violator is earning a rate return on the savings until the penalty is paid. This future value of the benefit is given as:

$$(21) \quad FV_{BEN} = EC_{BEN} \times (1 + E_m)^P$$

where: $P =$ the number of months between the noncompliance date and the penalty payment date

4. Calculations for the Cash Flow Table for Output Option 3

The model employs the procedures described above to calculate the economic benefit from delayed compliance as reported in the summary results in output Options 1 and 2 and the last page of Option 3. Slightly different procedures are used to calculate the values in the detailed cash flow tables provided for Option 3. The table illustrates tax effects and discounting in a sequence that is different from that used by the program to create the summary. The following discussion explains the additional calculations used to

create the tables. Note that the difference between the delay case cash flows and the on-time case cash flows derive from inflation and differential tax impacts.

a. Annual Cash Flows and Tax Effects

Each table presents annual, undiscounted expenses both before and after tax effects for each year. After-tax annual costs are calculated as follows:

$$(22) \qquad \text{TXSVOM}_j = - \text{OM}_j \times (1 - \text{MTR}_j)$$

The negative sign associated with the annual expenditure denotes a cash outflow.

For each year the tables also present the depreciation amount and the undiscounted depreciation tax benefit. The tax benefit is calculated as follows:

$$(23) \qquad \text{TXSVDP}_j = \text{DEP}_j \times \text{MTR}_j$$

The depreciation tax savings is positive because it is a cash inflow.

b. Treatment of the One-Time Nondepreciable Expenditure

If the one-time nondepreciable expenditure is not tax-deductible, it appears as part of the investment net of ITC at year zero:

$$(24) \qquad \text{INV} = - \text{EXP} - (\text{PV}_{\text{II}} - \text{ITC})$$

Note again that negative signs are used to denote cash outflows.

If the one-time nondepreciable expenditure is tax-deductible, it appears in the annual cost column at year zero and its after-tax value appears as after-tax annual cost. Thus,

$$(25) \qquad \text{TXSVOM}_0 = - \text{EXP} \times (1 - \text{MTR}_j)$$

c.   Discounting

and $INV = -(PV_{II} - ITC)$

Each table shows the present value of the after-tax annual cash flows. The table also lists the discount factors used in calculating each present value. For each year j, the discount factor is calculated as follows:

(26) $$DF_j = \frac{1}{(1 + E)^{(j-1/2)}}$$

where: DF_j =   the project discount factor applied to after-tax annual cash flows and depreciation tax savings in year j

$E =$ the annual discount rate

The discount factor equals 1.0 for year zero, since this is the year to which you are discounting and cash flows occurring in this year are already in present-value terms.

The table displays the discounted value of each annual cash flow. These are calculated by applying the discount factors to the appropriate cash flows for each year j:

(27) $PV1_j = TXSVOM_j \times DF_j$

(28) $PV2_j = TXSVDP_j \times DF_j$

where: $PV1_j$ =   the present value of after-tax annual costs in year j
and: $PV2_j$ =   the present value of the depreciation tax savings in year j

d.   Aggregating Present Values

For each year, the tables list the annual present value, which is the sum of (1) the investment net of ITC, (2) the present value of after-tax annual costs, and (3) the present value of depreciation tax savings. A negative figure denotes a net cash outflow or cost; a positive figure is a net cash inflow or savings:

(29) $PV_j = INV + PV1_j + PV2_j$

The final figure at the bottom of the cash flow table represents the sum of all the annual present value totals. This sum is equal to the total present value of compliance from equation (14). In each cash flow table, the negative sign is used to indicate that this present value represents a net cash outflow. In the on-time case table, the present value is expressed as of the noncompliance date, and in the delay case table, the present value is expressed as of the compliance date.

D.   SAMPLE CALCULATION OF ECONOMIC BENEFIT

This section illustrates BEN's calculation of the economic benefit of delayed compliance for a hypothetical noncomplying firm. The inputs are as follows:

1) A.	Case Name	Entity X Example
B.	Statute	2. Clean Air Act - Mobile Source
C.	Profitability Status	1. For-Profit
D.	Filing Status	1. C-Corporation
2)	Capital Investment	$405,000, 1997 dollars, recurring
3)	One-Time Nondepreciable Expenditure	$210,000, 1997, tax-deductible
4)	Annual Expense	$85,750, 1997 dollars
5)	Date of Noncompliance	February 1994
6)	Date of Compliance	August 1997
7)	Penalty Payment Date	April 1998
8)	Useful Life	15 years
9)	Marginal Tax Rate - 1986 and Before	49.6 percent
10)	Marginal Tax Rate - 1987 to 1992	38.6 percent
11)	Marginal Tax Rate - 1993 and Beyond	39.4 percent
12)	Inflation Rate	1.8 percent
13)	Discount Rate: WACC	10.6 percent

1.   First Cycle Cash Flows

The initial step in calculating the economic benefit of delayed compliance is to lay out all the cash flows that result from on-time compliance, including both direct costs and indirect financial impacts. First, BEN deflates the dollar input amounts -- capital investment, one-time nondepreciable expenditure, and annual cost -- from 1997 dollars to 1994 dollars (noncompliance-year dollars) using the 1.8 percent inflation rate. The amounts are deflated over three years by dividing by 1.054978 (one plus the inflation rate, to the third power) as indicated in equation (1).

The inputs and the deflated amounts are given in the following table:

Input	Input Dollar Amounts (Delay Case) (1997 dollars)	Deflated Values (On-Time Case) (1991 dollars)
Capital Investment	405,000	383,894
One-Time Nondepreciable Expenditure	210,000	199,056
Annual Expense	85,750	81,281 *
* Although this figure is deflated to year zero, BEN assumes annual expenses occur mid-year. The 6 month inflation calculation is shown on page A-29.		

BEN then calculates the on-time cash flows associated with these inputs, expressed in noncompliance-year dollars, and the delay case cash flows associated with these inputs expressed in compliance-year dollars. Exhibit A-2 reports the cash flows on both a before-tax and an after-tax basis, and also on a present value basis. BEN displays the cash-flow table shown in Exhibit A-2 as part of output Option 3. Each table is divided into two halves, and the years of the useful life of the capital investment are printed in the first column of each half.

The second column of the top half of each table includes the investment outlay ($383,894 for the on-time case; $408,629 for the delay case) net of the investment tax credit. In this example, since both the on-time and delay cases occur after 1985, the investment tax credit (ITC) is zero for both cases. Thus, the investment net of ITC in the second column is the sum of the one-time nondepreciable expenditure (zero) and the capital investment net of the ITC. This total is reported as a negative cash flow, as are all other cash outflows shown in the tables.

```
  ENTITY X EXAMPLE                          BEN VERSION 4.4 JULY 1, 1997


                         ON-TIME CASE CASH FLOWS
                      FIRST CYCLE CASH FLOWS BASED ON
                 A TOTAL INITIAL OUTLAY OF  $       383894
              AS OF THE BEGINNING OF THE PERIOD OF NONCOMPLIANCE


  YEAR  INVESTMENT                  DEPRECIATION    DEPREC   PRESENT VALUE
          NET OF    DEPRECIATION        TAX        DISCOUNT  OF DEPREC TAX
          ITC ($)       ($)         SAVINGS ($)    FACTOR    SAVINGS ($)
    0     -383894            0               0     1.0000            0
    1           0        54843           21608      .9509        20547
    2           0        94016           37042      .8597        31847
    3           0        67155           26459      .7773        20568
    4           0        47968           18899      .7028        13283
    5           0        34261           13499      .6355         8578
    6           0        34261           13499      .5746         7756
    7           0        34261           13499      .5195         7013
    8           0        17130            6749      .4697         3170
    9           0            0               0      .4247            0
   10           0            0               0      .3840            0
   11           0            0               0      .3472            0
   12           0            0               0      .3139            0
   13           0            0               0      .2838            0
   14           0            0               0      .2566            0
   15           0            0               0      .2320            0


  YEAR     ANNUAL      AFTER-TAX    PROJECT   PRESENT VALUE    TOTAL
           EXPENSES     ANNUAL      DISCOUNT    AFTER-TAX     PRESENT
                         COST       FACTOR      O&M ($)      VALUE ($)
    0      -199056      -120628     1.0000      -120628      -504522
    1       -82010       -49698      .9509       -47256       -26710
    2       -83486       -50592      .8597       -43496       -11650
    3       -84989       -51503      .7773       -40035       -19468
    4       -86518       -52430      .7028       -36850       -23567
    5       -88076       -53374      .6355       -33918       -25340
    6       -89661       -54335      .5746       -31219       -23463
    7       -91275       -55313      .5195       -28735       -21723
    8       -92918       -56308      .4697       -26449       -23279
    9       -94590       -57322      .4247       -24344       -24344
   10       -96293       -58354      .3840       -22408       -22408
   11       -98026       -59404      .3472       -20625       -20625
   12       -99791       -60473      .3139       -18984       -18984
   13      -101587       -61562      .2838       -17473       -17473
   14      -103416       -62670      .2566       -16083       -16083
   15      -105277       -63798      .2320       -14803       -14803
                                                            _____


     PRESENT VALUE OF PURCHASING THE INITIAL
     POLLUTION CONTROL EQUIPMENT ON-TIME AND
     OPERATING IT THROUGHOUT ONE USEFUL LIFE        $     -814440
```

```
ENTITY X EXAMPLE                        BEN VERSION 4.4 JULY 1,1997


                    DELAY CASE CASH FLOWS
               FIRST CYCLE CASH FLOWS BASED ON
            A TOTAL INITIAL OUTLAY OF  $      408629
            AS OF THE END OF THE PERIOD OF NONCOMPLIANCE


YEAR   INVESTMENT                DEPRECIATION   DEPREC   PRESENT VALUE
        NET OF    DEPRECIATION       TAX       DISCOUNT  OF DEPREC TAX
        ITC ($)       ($)        SAVINGS ($)    FACTOR    SAVINGS ($)
   0     -408629          0             0      1.0000           0
   1           0      58377         23000       .9509        21870
   2           0     100073         39429       .8597        33899
   3           0      71481         28164       .7773        21893
   4           0      51058         20117       .7028        14139
   5           0      36468         14369       .6355         9131
   6           0      36468         14369       .5746         8256
   7           0      36468         14369       .5195         7465
   8           0      18234          7184       .4697         3375
   9           0          0             0       .4247            0
  10           0          0             0       .3840            0
  11           0          0             0       .3472            0
  12           0          0             0       .3139            0
  13           0          0             0       .2838            0
  14           0          0             0       .2566            0
  15           0          0             0       .2320            0


YEAR     ANNUAL     AFTER-TAX   PROJECT   PRESENT VALUE    TOTAL
        EXPENSES     ANNUAL     DISCOUNT    AFTER-TAX     PRESENT
                      COST       FACTOR      O&M ($)     VALUE ($)
   0     -211882    -128400     1.0000      -128400      -537029
   1      -87293     -52900      .9509       -50301       -28431
   2      -88865     -53852      .8597       -46299       -12400
   3      -90464     -54821      .7773       -42615       -20722
   4      -92093     -55808      .7028       -39224       -25085
   5      -93750     -56813      .6355       -36103       -26972
   6      -95438     -57835      .5746       -33231       -24975
   7      -97156     -58876      .5195       -30587       -23122
   8      -98905     -59936      .4697       -28153       -24778
   9     -100685     -61015      .4247       -25913       -25913
  10     -102497     -62113      .3840       -23851       -23851
  11     -104342     -63231      .3472       -21953       -21953
  12     -106220     -64369      .3139       -20207       -20207
  13     -108132     -65528      .2838       -18599       -18599
  14     -110079     -66708      .2566       -17119       -17119
  15     -112060     -67908      .2320       -15757       -15757
                                                        _____

 PRESENT VALUE OF DELAYING THE PURCHASE
 OF THE INITIAL POLLUTION CONTROL EQUIPMENT
 AND OPERATING IT THROUGHOUT ITS USEFUL LIFE          $      -866915
```

The third column of the top half presents the annual depreciation in years 1 through 8. The depreciation amount is based on the double declining depreciation method (with half-year convention). The tax savings from each depreciation amount, which is in the fourth column, is calculated using equation (23). It equals the product of the depreciation amount and the applicable marginal tax rate. The depreciation discount factors in the fifth column are based on an annual discount rate of 10.6 percent, the rate used for all cash flows. Since annual cash flows occur at mid-year in the model, their values are discounted from the middle of the year. For example, the discount factor in year 1 is equal to:

$$\frac{1}{(1.106)^{1/2}} = 0.95087$$

The sixth column presents the present value of the depreciation tax savings, obtained by multiplying the depreciation tax savings (column 4) and the discount factor (column 5).

The second column in the bottom half of the table lists the annual costs, inflated by 1.8 percent per year. Since annual expenses occur at mid-year in the model, the annual amount for year 1 for the on-time case is calculated by inflating the annual amount in noncompliance-year dollars for one-half year (see Equation 7):

$$\$81,281 \times (1.018)^{1/2} = \$82,010$$

The one-time nondepreciable expenditures, because they are tax-deductible, are reported in this column at year 0 ($199,056 for the on-time case, and $211,882 for the delay case).

The after-tax annual and one-time nondepreciable expenses are in the third column. The figures in this column are calculated by multiplying the annual costs by a factor equal to one minus the marginal tax rate. The discount factors in the fourth column are based on a discount rate of 10.6 percent. These discount rates are identical to those applied to the depreciation tax savings.

The fifth column, which is calculated using equation (28), contains the present value of the annual cash flows (column 3 times column 4). The last column provides the totals of the present values of the investment net of ITC (if applicable), depreciation tax savings, and after-tax annual costs for each year.

The last dollar figure in each table (negative $814,440 for the on-time case, and negative $866,915 for the delay case) is the sum of the annual present-value cash flows for one useful life. BEN reports the value for the on-time case as the first figure (A) in the output shown in Exhibit A-3. This output is provided for output Option 2 and as the last page of Option 3. Note that costs and benefits are both shown as positive numbers in Exhibit A-3.

2.   Including Replacement Cycles

The present value of purchasing and operating pollution control equipment must include future replacement of the equipment. BEN uses equations (15a), (15b), and (15c) to compute the present value cost of all replacement cycles from the second cycle of cash flows. To calculate the second cycle of cash flows, BEN performs the same calculations as presented at the beginning of this section except the one-time, nondepreciable expenditure is $0. BEN then inflates this figure forward 15 years to the date when the equipment will require replacement.

$$= \quad \$693,813 \times (1.018)^{15}$$
$$= \quad \$693,813 \times 1.3068227$$
$$= \quad \$906,690$$

Next BEN calculates the cash flows for all replacement cycles based on this "second cycle" figure.

$$= \quad \$906{,}690 \text{ x } \cfrac{1}{1 - \left(\cfrac{1.018}{1.106}\right)^{15}}$$

$$= \quad \$906{,}690 \text{ x } 1.4051456$$

$$= \quad \$1{,}274{,}032$$

The total present value cost of complying with environmental regulations on time is the present value of the original cycle cash flows plus the present value of all replacement cycle cash flows, as of the noncompliance date:

$$= \quad \$814{,}440 \; + \; \frac{\$1{,}274{,}032}{(1.106)^{15}}$$

$$= \quad \$814{,}440 \; + \; \frac{\$1{,}274{,}032}{4.5323862}$$

$$= \quad \$814{,}440 + \$281{,}095$$

$$= \quad \$1{,}095{,}535$$

This is the second figure (B) reported in Exhibit A-3. The on-time compliance cost total is equal to the sum of (1) the total present value cost of investing in and operating pollution control equipment over the initial useful life cycle and all future replacement cycles and (2) the one-time expenditure.

OUTPUT OPTION 2

```
ENTITY X EXAMPLE                      BEN Version 4.4 JULY 1, 1997


A.  VALUE OF EMPLOYING POLLUTION CONTROL ON-TIME AND
    OPERATING IT FOR ONE USEFUL LIFE IN 1994 DOLLARS $      814440

B.  VALUE OF EMPLOYING POLLUTION CONTROL ON-TIME AND
    OPERATING IT FOR ONE USEFUL LIFE PLUS ALL FUTURE
    REPLACEMENT CYCLES IN 1994 DOLLARS                 $     1095535

C.  VALUE OF DELAYING EMPLOYMENT OF POLLUTION
    CONTROL EQUIPMENT BY 42 MONTHS PLUS ALL FUTURE
    REPLACEMENT CYCLES IN 1994 DOLLARS                 $      819597

D.  ECONOMIC BENEFIT OF A  42 MONTH DELAY
    IN 1994 DOLLARS (EQUALS B MINUS C)                 $      275938

E.  THE ECONOMIC BENEFIT AS OF THE PENALTY PAYMENT
    DATE,   50 MONTHS AFTER NONCOMPLIANCE              $      419879
                                                             =========



    ->->->->->->  THE ECONOMIC BENEFIT CALCULATION ABOVE  <-<-<-<-<-<-
                  USED THE FOLLOWING VARIABLES:
       USER SPECIFIED VALUES
       ---------------------
     1A. CASE NAME = ENTITY X EXAMPLE
     1B. PROFIT STATUS =                           FOR-PROFIT
     1C. FILING STATUS =                           C-CORPORATION
      2. INITIAL CAPITAL INVESTMENT (RECURRING)= $    405000  1997 DOLLARS
      3. ONE-TIME NONDEPRECIABLE EXPENDITURE =   $    210000  1997 DOLLARS
         (TAX-DEDUCTIBLE EXPENSE)
      4. ANNUAL EXPENSE =                         $     85750  1997 DOLLARS
      5. FIRST MONTH OF NONCOMPLIANCE =                 2, 1994
      6. COMPLIANCE DATE =                              8, 1997
      7. PENALTY PAYMENT DATE =                         4, 1998

         STANDARD VALUES
         ---------------
      8. USEFUL LIFE OF POLLUTION CONTROL EQUIPMENT =    15 YEARS
      9. MARGINAL INCOME TAX RATE FOR 1986 AND BEFORE =  49.6 %
     10. MARGINAL INCOME TAX RATE FOR 1987 TO 1992 =     38.6 %
     11. MARGINAL INCOME TAX RATE FOR 1993 AND BEYOND =  39.4 %
     12. ANNUAL INFLATION RATE =                          1.8 %
     13. DISCOUNT RATE: WEIGHTED-AVERAGE COST OF CAPITAL  10.6 %
```

3. Cost of Delayed Compliance

The present value cost of delayed compliance is derived from the delay case cash flow table. The replacement cycle cash flows are calculated using the same formulae as the replacement cycle analysis in Section 2:

$$= \quad \$738,517 \times (1.018)^{15}$$
$$= \quad \$738,517 \times 1.3068227$$
$$= \quad \$965,111$$

The replacement cycle cash flows thus total:

$$= \quad \$965,111 \times \frac{1}{1 - \left(\dfrac{1.018}{1.106} \right)^{15}}$$

$$= \quad \$965,111 \times 1.4051456$$
$$= \quad \$1,356,122$$

The total present value of delayed compliance (as of the compliance date) is the present value of the original cycle cash flows plus the present value of all replacement cycles' cash flows:

$$= \quad \$866,915 + \frac{\$1,356,122}{(1.106)^{15}}$$

$$= \quad \$866,915 + \frac{\$1,356,122}{4.5323862}$$

$$= \quad \$866,915 + \$299,207$$
$$= \quad \$1,166,122$$

A monthly discount rate is used to discount the delay case present value total to the noncompliance date.

The discount rate is converted to monthly equivalents as follows:

$$E_m = (1 + E)^{1/12} - 1$$

$$= (1 + 0.106)^{1/12} - 1$$

$$= 0.0084312$$

In this example, compliance was delayed 42 months from February 1994 to August 1997. BEN uses equation (19) to calculate the present value cost of delayed compliance for the 42 month delay as of the noncompliance date:

$$= \frac{\$1,166,122}{(1.0084312)^{42}}$$

$$= \frac{\$1,166,122}{1.4227988}$$

$$= \$819,597$$

This is the third figure (C) reported in the output shown in Exhibit A-3.

4.   Economic Benefit of Delay

The economic benefit of the 12-month delay, valued as of the noncompliance date, is simply the difference between the present value costs of complying on time and complying after the delay:

$$= \$1,095,535 - \$819,597$$

$$= \$275,938$$

This is the fourth figure (D) reported in Exhibit A-3. It is the difference between the two preceding

figures (B and C) in the output.

Finally, the economic benefit is valued as of the penalty payment date of April 1998, which is 50 months after the noncompliance date. The economic benefit is brought forward using the discount rate, which is compounded monthly from the noncompliance date to the penalty payment date.

This value of the benefit at the time the penalty is paid is calculated as in equation (21):

$$= \quad \$275{,}938 \times (1 + E_M)^{50}$$
$$= \quad \$275{,}938 \times (1 + 0.0084312)^{50}$$
$$= \quad \$275{,}938 \times 1.5216462$$
$$= \quad \$419{,}879$$